EFFECTS OF ENERGY SOURCES SUPPLEMENT FOR CAMELS FED BERSEEM HAY ON: 2. METABOLISM OF WATER AND SOME MINERAL ELEMENTS.

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SUMMARY

An experiment was conducted to study the effect of barley grains and date stones as energy - source supplements with Berseem hay on the metabolism of water and some mineral elements of camels. Three one-humped female camels with an average body weight 467 kg were used in 3 x 3 Latin Square design experiment. The treatments were: only *ad lib*. Berseem hay (diet H); *ad lib*. Berseem hay + 100% of maintenance energy requirements covered by crushed barley grains (diet B) and *ad lib*. Berseem hay + 100% of maintenance energy requirements covered by equal portions of crushed barley grains and crushed date stones (diet BD). The results indicated that camels fed B diet showed higher ($P \leq 0.01$) total water intake than diets H and BD. Retained water was ($P \leq 0.01$) higher with B diet than the other two groups (95.52 *vs.* 55.41 and 54.22 ml/kg$^{0.82}$ for camels fed B, H and BD diets, respectively)). The energy feed source led to a significant reduction of free water intake in relation to dry matter intake (DMI), total digestible nutrients intake (TDNI), digested crude protein intake (DCPI), nitrogen retained (NR) and nitrogen digested (ND). Moreover, camels fed B diet retained significant higher water in relation to free water intake, DMI, TDNI, DCPI and NR than the other two groups. Camels fed B diet retained higher levels of Na and K ($P \leq 0.01$) and ($P \leq 0.05$), respectively compared to other animals. Meanwhile, camels fed B diet retained more Zn ($p \leq .001$) while camels fed BD diet retained more Co ($P \leq 0.05$). Camels fed BD diet showed higher Na and K serum concentrations than the other two groups. However, the B group was superior in serum concentration of Cu and Co. The difference in serum Zn concentration between the three groups was not significant. It could be concluded that energy supplementation (especially barley grains) improved camel's utilization of water and mineral elements (Na, K, Cu, Zn, Co) under the conditions of this study.

***Keywords:** camels, energy, date stones, water and mineral utilization.*

INTRODUCTION

It is essential to know the quantity and the quality of the diet actually consumed by an animal. These two factors are largely depended upon the available feed resources (Kearl, 1982). Until recently our knowledge about the nutrition and feeding of camels was restricted to some field observations on the range, reviewed by Newman (1979).

Yacout and El-Badawi (2001) showed that dromedary have higher demand to dietary energy rather than protein. However, Horn and McCollum (1987) suggested that supplementation induced depression in forage intake with increasing forage quality. However, few reports recorded interactions between forage quality and supplemental energy.

The camel has a very large drinking capacity not to store up water for future needs, but to replenish water already lost via urine, feces and evaporation (Fillali and Shaw, 2004). Van Saun (2006) reported that, total water requirement is determined by body weight, physiological status, level of activity, production level, dietary composition and environmental conditions.

It is well known that water and energy economies are much more frugal in desert adapted species and breeds in comparison to close relatives from more moderate climates (Macfarlane & Howard, 1972). It is also well established that the lower energy requirement of desert species and breeds results from a lower metabolic rate (Silanikove, 1987). As the crude protein content of diet fell from 12 to 4%, digestible energy intake declined by 60% and heat reduction by 20% (Rogerson, 1963).

Farid et al. (1985) found that camels needed about 40% to 60% less water than sheep whether expressed per unit dry matter intake or per unit body mass. Camels under similar treatments decreased their free water intake as the roughage protein in the diet decreased. Also, they reported that camels lost less water in faeces and urine than sheep when fed diets differing in energy content ration or in protein content or when water deprived. In addition, they concluded that both decreased energy density and protein content will affect dry matter intake, reducing the animal 's need for free drinking water.

Energy is carried through tissues in a stream of water which transports them from gut through cells and out to the renal filter or evaporative cooler (MacFarlan and Howard, 1972). However, Faye et al. (1991) observed that there is a high interaction between mineral absorption and quality of diet with well balanced diet in terms of energy and protein being crucial in avoiding deficient mineral status.

Barley grains and date stones consider the main important feedstuffs as energy supplement for livestock under Egyptian desert conditions. Few studies regarding to the effect of either energy levels (Yacout and El-Badawi, 2001 and Shawket and Ahmed, 2001), or energy sources (Shawket, 1999) on camel performance have been done. Knowledge of feeding camels under normal conditions (good health, no feed deprivation, no hydration, no salinity water or underfeed stress, no heat stress) is important to understanding its feeding behavior to be as a guide towards better management camels.

As far as camels are concerned, very limited information are available on mineral utilization hence the following study was undertaken. So, this study was conducted to investigate the effects of some energy sources; crushed barley grains (100% of maintenance energy requirements) and partial substitution of crushed barley grains by crushed date stones at level of 50%, on the metabolism of water and some mineral elements of camels fed Berseem hay as a basal diet.

MATERIALS AND METHODS

The present experiment was carried out at Maryout Desert Research Station of the Desert Research Center, 35 Km south of Alexandria city. Traditionally, it represented the eastern boundaries of the western coastal rangelands of Egypt.

Animals and experimental diets

Three healthy female camels (*C. Dromedarius)* averaged 467 ± 29.06 kg live body weight (seven years old) were used in arrangement of 3 X 3 Latin square design. The animals were housed individually in confined pens for 45 days as an adaptation period followed by 13 days for collection. Three diets (H, B. and BD) were tested throughout the whole experiment.

The tested diets were as follows: 1- *Ad lib* Berseem hay as a sole feed……. (diet H). 2- Crushed barley grains to cover 100 % of maintenance energy requirements (MER) according to Farid *et al.* (1990) + *ad lib* Berseem hay…….. (diet B). 3- Crushed barley grains to cover 50 % of MER + crushed date stones as 50 % of MER + *ad lib* Berseem hay. ……. (diet BD).

All animals were offered their experimental diets once daily at 09.00 a.m. and any feed refusals were collected next day, and then weighed to determine the actual voluntary feed intake. Camels were housed in separate metallic cages (Kewan, 2003) during collection period. Total feces were collected daily and 5% was sampled, dried at 105 °C for 12 hr, then ground and kept for chemical analyses. Urine was collected using a metal funnel fitted around the female external genitalia (Shawket, 1976). Urine was collected in plastic containers containing 50 ml solution of 50 % H_2SO_4 and subsample 10 % were taken and composited then frozen until analyzed. Representative composite samples from the offered feed ingredients were collected and kept for analyses. The composition of experimental feeds and diets are presented in Table (1). Fresh water was offered for each animal twice daily and water intake was determined. Daily total mineral elements intake via water and feeds consumed and the excreted tested minerals via urine and faeces were estimated. Apparent absorption (AA) coefficients for sodium, potassium, cupper, zinc and cobalt were calculated as Reid (1980). Apparent retention of the same mineral elements was determined.

Blood samples

Blood samples were taken from each animal at the end of the collection period of each digestibility trial before morning meal as illustrated in the previous experiment (Kewan *et al.*, 2009). The blood was allowed to clot and after centrifugation, the serum was separated and stored at –20° C until analysis.

Analytical methods

The proximate constituents of feed ingredients, feces and nitrogen in urine were determined according to AOAC (1996). The minerals analysis of Na, K, Cu, Zn, Co in feedstuffs, drinking water, blood serum, faeces and urine were determined according to standard methods. The concentrations of sodium and potassium were determined by using flame photometer as described by Jackson (1958). The concentrations of copper, zinc and cobalt were measured by atomic absorption spectrophotometer (Pye Unicam model 220) according to Chapman and Patt (1961).

Statistical Analyses

Data were tested statistically using SAS (1988). Mean differences were compared by Duncan New Multiple Range Test (Duncan, 1955).

RESULTS AND DISCUSSION

Chemical composition of feedstuffs

Results summarized in Table (1) indicate that the experimental diets (B) and (BD) had a comparable level of CP around (11%), however both diets attained lower CP, CF and ash contents compared to H diet. Both B and BD diets were higher in NFE than H diet.

Mineral content of the ingredients and experimental diets are presented in Table (2). Mineral content of all experimental ingredients (hay, barley grains and date stones) revealed higher variation of minerals content compared to that reported by Hassan *et al.*, (2008) which may be due to factors such as plant maturity, varieties, season of the year, metal in the soil, fertilization, physical and chemical processes which affected mineral uptake by roots and translocation within plant (Underwood, 1977). Mineral content of the experimental diets revealed that H diet had higher Na, K and Cu content comparing to B and BD diets. On the other hand all diets were comparable regarding to Zn and Co.

Table (1): Chemical composition (on DM basis) of the experimental feedstuffs and diets.

Item	Experimental feeds*			Experimental diets		
	H	BG	DS	H	B	BD
DM %	89.89	89.47	91.55	89.89	89.71	90.81
OM %	87. 40	96.69	98.62	87. 40	91.48	93.14
CP %	12.43	9.46	9.99	12.43	11.12	11.16
CF %	28.03	6.84	12.82	28.03	18.72	19.09
EE %	2.78	2.22	7.78	2.78	2.53	3.91
Ash %	12.60	3.31	1.38	12.60	8.52	7.54
NFE %	44.16	78.17	68.03	44.16	59.11	58.97
GE,MJ/kg DM**	17.14	18.19	19.93	17.14	17.60	18.22

* *H: Berseem hay; BG: Barley grains; DS: Date stones.*

** *Calculated according to Maff (1975), using the following equation:*

GE, MJ/kg DM = 0.0226 CP + 0.0407 EE + 0.0192 CF + 0.0177 NFE.

Water utilization

Data of water utilization (ml/ $kg^{0.82}$) by camels fed the experimental diets are presented in Table (3). The present results showed that free water intake as ml/g DMI was higher ($P<0.01$) in H camel group than their mates supplemented with energy sources. This result is in contrast with the results reported by Sooud *et al.* (1989) who found that the free water intake was more related to the dry matter intake. They noted that so camels fed restricted diet consumed significantly more free water than their mates receiving the all hay or the concentrate-straw diets, being 2.87 vs., 2.08 and 2.20 ml/g DMI, respectively. They also, indicated that these differences may be due to one or more of the following reasons; 1) Feeding regimen for each experiment, 2) The differences between barley or date stones and concentrate feed mixture in its physical properties 3) Season of conducting the experiment.

Camels fed B ration showed higher total water intake ($P \leq 0.01$) expressed as ml per kg metabolic body mass than other two groups. This result was regarded to the amount of DMI. This result indicated that the amount of total water intake increased due to barley grains supplementation as a source of energy which led to increase the total voluntary feed intake and consequently increased the DMI. More and Sahni (1981) also concluded that dry matter intake is considered to be a major factor affecting water intake and it is customary to express the water intake (the sum of water drunk and water contained in feed). They added that, the inadequate supply of drinking water restricted the dry matter intake.

Fowler (1998) reported that, the water requirement has been related to energy intake (1 ml/kcal of metabolizable energy intake) or metabolic body mass (122 ml/kg $BW^{0.82}$). More general rule of thumb for water intake is two to three times dry matter intake or 3% (adult maintenance) to 8% (growth, lactation level) of body weight daily. Water intake increased in hot weather and humid conditions to approximately 10–15% of body weight daily Macfarlane (1964) found that Somali camels required 61.0 ml water/$kg^{0.82}$/day; however, Ghosh (1987) reviewed that water requirement for camel was 185 ml /$kg^{0.82}$/day. Kandil *et al.* (1985) reported that water intake expressed as ml/$kg^{0.82}$ was 92.0 and 2.52 as ml/ g DMI for camels received *ad lib* Berseem hay. While water excreted in faeces were 32.0 ml/$kg^{0.82}$ and 25.0 ml/$kg^{0.82}$ via urine. On the other hand, Abou Akkada (1988) reviewed that the quantity of water required by the camel depends on the amount of moisture in the feed, the temperature and the work done. Camels watered daily consumed 3 to 8 gallons (13-36 liters) or 52.6 ml/$kgw^{0.82}$ and 2.29 ml/gm dry matter, however, water excreted was 23.2 ml/$kgw^{0.82}$ in faeces and 12.3 ml/$kg^{0.82}$ in urine. The differences between our recent results and authors results may be due to the previously reasons which were indicated by Sooud *et al.* (1989) (see page 5).

Table (2): Mineral content of the experimental diets (as DM basis).

Item	Experimental feads*			Experimental diets			Drinking water
	H	BG	DS	H	B	BD	
Macro-minerals,%							
Na	2.39	0.86	0.71	2.39	1.72	1.59	0.04
K	1.85	0.65	0.71	1.85	1.32	1.27	0.003
Micro-minerals, mg/kg							
Cu	40.91	16.41	52.38	40.91	30.14	37.66	0.084
Zn	25.01	31.50	21.04	25.01	27.86	25.64	0.46
Co	20.43	11.26	29.16	20.43	16.40	20.32	0.013

* *H: Berseem hay; BG: Barley grains; DS: Date stones.*

Faecal water (ml/$kg^{0.82}$) excreted by camels fed diet B was lower than that excreted by camels fed diets H or BD but not differ significantly. Urine water excreted by camels fed B was lower than that excreted by camels of the other two groups ($P \leq 0.05$). Consequently camels fed diet B excreted lower ($P \leq 0.05$) amount of water (43.10 *vs.* 50.23 and 59.63 ml/$kgw^{0.82}$ for camels fed diets B, DH and H, respectively) and thus retained higher ($P \leq 0.01$) amount of water (95.52 ml/$kgw^{0.82}$), compared to camels of the other two groups. MacFarlane *et al.* (1963) and Abou El-Nasr *et al.* (1988) emphasized that kidney controls water loss in two ways: by the absolute concentration achieved and the second is by the reduction in the flow of urine.

Total water excretion was higher in H camel group than that received sources of energy, and comparable to that found by Kandil *et al.* (1985) that camels received *ad lib* Berseem hay excreted water 32.0 ml/$kg^{0.82}$ in faeces and 25.0 ml/$kg^{0.82}$ via urine. This may be due to the higher content of ash in H diet comparing to B or BD diets. On the other hand, Sooud (1980) found that increasing the ration energy concentration reduced substantially the water loss in faeces from 46 to 31% of water intake in camels. Moreover, camels had the capacity to reduce water loss from the body in urine, faeces and by evaporation when kept on a diet consisting of dates and hay (Schmidt-Nielsen *et al.*, 1956). These previously findings explained the decrease ($P<0.05$) of total water excretion of camels fed B and BD diets compared to camels group fed H diet.

The higher ($P<0.001$) retained water for B group may be attributed to one or both of the following reasons; first higher water holding capacity for hay and barley grains comparing to date stones. the second is increasing of heat increment that result from hay fermentation which may lead to increase water needed for body cooling system (Gihad *et al.* 1989).

Table (3): Water utilization pattern of camels fed the experimental diets.

Item	Experimental diets			SEM	P value
	H	B	BD		
Average $Bw^{0.82}$	168.8	168.2	165.9	4.41	0.969
Water intake:					
Dietary water,ml/$kgw^{0.82}$	3.88^{a}	5.84^{b}	5.19^{b}	0.32	0.008
Free water intake (FWI)					
ml/$kgw^{0.82}$	111.3^{b}	132.7^{a}	99.0^{b}	5.70	0.017
ml/g DMI	3.24^{a}	2.60^{ab}	2.19^{b}	0.17	0.009
Total water intake					
ml/$kg^{0.82}$	115.3^{b}	138.7^{a}	104.3^{b}	5.85	0.016
ml/g DMI	3.35^{a}	2.72^{b}	2.30^{b}	0.17	0.009
Water excretion					
Faecal water					
ml/$kgw^{0.82}$	32.84	35.81	28.09	2.08	0.426
% intake	28.52	25.18	26.98	2.12	0.110
Urine water					
ml/$kgw^{0.82}$	26.81^{a}	27.25^{b}	22.16^{ab}	1.75	0.055
% intake	23.37^{b}	17.44^{a}	21.21^{b}	1.90	0.012
Total water excretion					
ml/kg $w^{0.82}$	59.63^{a}	43.10^{b}	50.23^{ab}	2.97	0.044
% intake	51.89^{a}	31.11^{b}	48.19^{a}	3.44	0.002
ml/g DMI	1.73^{a}	0.85^{c}	1.11^{b}	0.13	0.000
Apparent Retained Water					
ml/$kgw^{0.82}$	55.41^{b}	95.52^{a}	54.22^{b}	7.21	0.001
% intake	48.11^{b}	68.89^{a}	51.81^{b}	3.44	0.002

H: Hay ad lib., B: Barley 100% of MER + Hay ad lib., BD: B: Barley 50% of MER + Date stones 50% of MER + Hay ad lib., SEM: Standard error mean.

a,b,c Means followed by different letters within each same row are significantly different.

Free water intake and water retained related to nutrients intake and nitrogen utilization were presented in Table (4). Camels fed on B and BD diets showed higher ($P<0.05$) intake of dry matter (DMI), total digestible nutrients (TDNI) and digestible crude protein (DCPI) compared to their mates fed on H diet (79.62, 55.75 and 4.70; 71.04, 50.24 and 4.15 *vs.* 53.88, 31.15 and 3.56 g/$kgw^{0.75}$ values of DMI, TDNI and DCPI of camel groups fed B, BD and H diets, respectively) as indicated by Kewan *et al.*, (2009). However, B and BD diets contained comparable CP levels (11.12 and 11.16, respectively), but less than that of hay diet (12.43%) and also, both of these groups showed higher ($P<0.05$) water intake (Table 3). These facts explain the present results that energy sources supplemented to camels fed hay leads to significant reduction ($P<0.05$) in free water intake in relation to DMI, TDNI, DCPI, NR and DN (Table 4). Moreover, camels fed on B diet showed higher ($P<0.05$) values of water retention in relation to free water intake (FWI), DMI, TDNI, DCP and NR than the other two groups. These may be due to the higher retained water of camels fed B diet *vs.* those fed H and BD diets (Table 3).

Table (4): Free water intake and water retained related to nutrients intake and nitrogen utilization.

Item	Experimental diets			SEM	P value
	H	B	BD		
DMI, g/d	5828^{b}	8549^{a}	7488^{a}	428	*
TDNI, g/d	3370^{b}	5990^{a}	5300^{a}	410	*
DCPI, g/d	384.7^{b}	505.7^{a}	438.0^{ab}	21.92	*
NR, g/d	7.50^{b}	10.00^{a}	10.95^{a}	0.54	*
DN, g/d	61.3^{b}	82.3^{a}	73.0^{ab}	3.72	*
Free water intake (FWI)					
ml/kg $w^{0.82}$	111.3^{b}	132.7^{a}	99.0^{b}	5.70	0.017
ml/g DMI	3.24^{a}	2.60^{b}	2.19^{b}	0.17	0.009
ml/g TDNI	5.60^{a}	3.72^{b}	3.10^{b}	0.39	0.001
ml/g DCPI	49.07^{a}	44.17^{ab}	37.47^{b}	2.11	0.049
ml/g NR	2510^{a}	2220b	1490^{c}	150.0	0.000
ml/g DN	307.0^{a}	271.7^{ab}	224.7^{b}	14.24	0.027
Apparent Retained Water (RW)					
RW; ml/kg $w^{0.82}$	55.41^{b}	95.52^{a}	54.22^{b}	7.21	0.001
RW/FWI %	49.79^{b}	71.93^{a}	54.51^{b}	3.59	0.002
ml/g DMI	$1.63a^{b}$	1.88^{a}	1.19^{b}	0.13	0.050
ml /g TDNI	2.81^{a}	2.68^{a}	1.69^{b}	0.21	0.034
ml/g DCPI	24.63^{ab}	31.77^{a}	20.50^{b}	2.03	0.041
ml /g NR	1250^{b}	1600a	810^{c}	120.0	0.001
ml/g DN	154.0^{ab}	195.3^{a}	123.0^{b}	12.84	0.037

H: Hay ad lib., B: Barley 100% of MER + Hay ad lib., BD: B: Barley 50% of MER + Date stones 50% of MER + Hay ad lib., SEM: Standard error mean.

$* P < 0.05$

A,b,c Means followed by different letters within each same row are significantly different.

Mineral balance:

The intake, excretion and balances of macro – elements (Na and K) are summarized in Table (5). Minerals are inorganic elements classified into two groups, macro minerals (g/day) or micro minerals (mg/day or g/day), based on daily amounts required. Although there are no data defining mineral requirements, there also is no data suggesting that camelids are distinctly different than other ruminants with regard to any specific mineral (Van Saun, 2006). Mineral content was generally high in camel's natural feeds (Idris and El-Shami, 1990) and it was reported that Potassium and sodium were found adequate for other livestock in most plants eaten by camels (Elmi, 1989). The present results indicated that total intake of Na and K are higher ($p \leq 0.05$) with B diet than the other two diets. This could be attributed to higher feed and water intake by camels fed diet B (Kewan *et al.*, 2009). Faecal Na and K are elevated in H and B fed camels, respectively than camels group fed BD diet but not significant, while urinary Na and K are higher ($p \leq .05$) in H fed camel group than other two groups. Total excretion of Na is highest significantly in hay fed animals. B fed camels retained higher levels of Na and K ($P \leq .01$) and ($P \leq .05$), respectively compared with the other two camel groups fed H and BD diets. These findings could be explained according to the previous mentioned results that camels fed B diet retained ($P<0.001$) water more than the other two camels groups. Changes in intake and excretion were reflected upon observed values for mineral retention. Ahmed *et al.* (1989) mentioned that Sodium and Potassium were excreted exclusively through the urine and also found that, apparent retentions were always positive even when camels were drinking the fresh water. It seems that, Sodium and water metabolism are closely related as reported by (Yagil, 1985); Dahlborn *et al.*, 1992).

Table (5): Macro- minerals utilization by camels fed different energy sources.

Item	Experimental diets			SEM	P value
	H	B	BD		
Average $BW^{0.75}$	109.0	108.6	107.1	2.79	0.968
Sodium (Na), mg/d					
Feed	139.3^{ab}	146.8^{a}	118.7^{b}	5.15	0.038
Drinking water	7.51^{b}	8.91^{a}	6.54^{b}	0.39	0.010
Total intake	146.8^{a}	155.7^{a}	125.2^{b}	0.90	0.030
Faeces, mg/d	33.14	29.30	31.04	1.57	0.672
Apparent absorption*, %	77.33	81.33	75.33	0.13	0.165
Urine, mg/d	23.37^{a}	13.79^{b}	17.37^{ab}	2.04	0.025
Total excretion	56.50^{a}	43.09^{b}	48.42^{ab}	2.56	0.074
Balance, mg/d	90.29^{b}	112.65^{a}	76.83^{b}	5.70	0.004
% intake	61.60^{b}	72.30^{a}	61.32^{b}	1.84	0.005
μg/kg $BW^{0.75}$	828.17^{b}	1037.90^{a}	722.07^{b}	49.42	0.002
Potassium (K), mg/d					
Feed	107.82^{ab}	113.07^{a}	94.60^{b}	3.59	0.071
Drinking water	0.5633^{b}	0.6667^{a}	0.4900^{b}	0.03	0.008
Total intake	108.38^{ab}	113.73^{a}	95.09^{b}	3.61	0.070
Faeces, mg/d	17.54	18.86	17.42	0.71	0.714
Apparent absorption, %	83.67	83.33	81.67	0.6	0.378
Urine, mg/d	17.21^{a}	12.42^{b}	14.96^{ab}	0.82	0.025
Total excretion	34.76	31.28	32.39	0.80	0.205
Balance, mg/d	73.62^{ab}	82.45^{a}	62.70^{b}	3.46	0.032
% intake	67.85^{b}	72.44^{a}	65.94^{b}	1.10	0.012
μg/kg $BW^{0.75}$	675.0^{ab}	759.7^{a}	590.2^{b}	29.87	0.036

H: Hay ad lib., B: Barley 100% of MER + Hay ad lib., BD: B: Barley 50% of MER + Date stones 50% of MER + Hay ad lib., SEM: Standard error mean.

**Apparent absorption % = 100 × (mineral intake – faecal mineral output) ÷ mineral intake (Reid 1980).*

a,b,c Means followed by different letters within each same row are significantly different.

Concerning to micro – minerals copper (Cu), zinc (Zn) and cobalt (Co) balances of the three experimental groups are presented in Table (6). Higher Cu and Co intake was recorded in BD diet followed by B diet fed camels then hay ones ($p \leq 0.05$), ($p \leq 0.01$) and ($p \leq 0.001$), respectively, which could be attributed to the higher ($p \leq 0.05$) DM intake of camels fed either B or BD diets than their mates fed H diet energy sources supplementation (79.62 and 71.04 *vs.* 53.88 g DM/$kgw^{0.75}$, respectively) as previously reported by Kewan *et al.* (2009).

In regard to mineral excretion, camels fed BD excrete ($P \leq 0.05$) more Cu (223.19 mg/d) than the other two camel groups. H and BD camel groups excrete comparable levels of Zn (82.74 and 83.83 mg /d, respectively) and higher ($P \leq 0.05$) than camel group fed B diet. B and BD camel groups excrete equal concentrations of Co, although the variations among three groups were not significant. Meanwhile, camels given B diet retained higher ($P \leq 0.001$) Zn while camels fed BD diet retained ($p \leq 0.05$) more Co compared to camel group fed H diet. Ahmed *et al.* (1989) reported that faeces were the main pathway for the excretion of calcium, zinc, manganese and copper. Faye and Bengoumi (1998) reported that Cupper absorption was 19.5 mg/day/100 kg LW and zinc absorption was 67.5 mg/day/100 kg LW. It is very difficult to use the plasma copper concentration to appreciate the nutritional status of camels. Most of the cupper excretion occurred by feces. This includes the non-absorbed part at the intestinal level and the endogenic part coming from previously absorbed minerals coming back in the intestinal tract. Only the difference between the intake and the excreta can be measured, i.e. a crude assessment of the apparent absorption. The quantity of copper excretion in feces was logically lower in the camel because of the lower total quantity of copper salt supplemented. The camels seemed to show a better use of copper intake in the post supplementation period by increasing the absorption and slowing the liver release. Camels have a lower normal level of the plasma zinc concentration and we can consider that the deficient threshold is below 40 μg/100 ml.

Excretion of zinc in urine being negligible, fecal excretion is the principal way for reporting endogenous and nutritional zinc. The quantity of fecal zinc was higher due to the slight difference of mineral intake. As a whole, zinc excretion was higher in camels which confirm the absence of deficiency in spite of low observed plasma zinc concentration in this species. So, it is clear that zinc requirements are lower in camels than in cows and the supply through the basal diet is sufficient. Because of the important enzyme activities in the camel kidney than liver (Bengoumi et al., 1997), one could consider that this organ could play a particular role in the storage of this trace element.

Table (6): Micro-minerals utilization by camels fed different energy sources.

Item	Experimental diets			SEM	P value
	H	B	BD		
Average $BW^{0.75}$	109.0	108.6	107.1	2.79	0.968
Copper (Cu)					
Feed	238.42^{b}	257.67^{ab}	281.86^{a}	8.54	0.097
Drinking water	1.58^{b}	1.87^{a}	1.37^{b}	0.08	0.010
Total intake	239.99^{b}	259.54^{ab}	283.23^{a}	8.52	0.099
Faeces, mg/d	146.70^{b}	166.95^{ab}	184.93^{a}	7.32	0.080
Apparent absorption, %	39.00	36.00	35.00	1.00	0.296
Urine, mg/d	31.81	34.07	38.25	2.35	0.591
Total excretion	178.52^{b}	201.01^{ab}	223.19^{a}	7.80	0.032
Balance, mg/d	61.48	58.53	60.05	2.15	0.887
% intake	25.66^{a}	22.53^{ab}	21.13^{b}	0.87	0.065
µg/kg $BW^{0.75}$	563.90	539.90	559.20	14.41	0.818
Zinc (Zn), mg/d					
Feed	145.76^{c}	238.21^{a}	192.02^{b}	14.02	0.001
Drinking water	8.63^{b}	10.24^{a}	7.52^{b}	0.45	0.010
Total intake	154.39^{c}	248.45^{a}	199.53^{b}	14.28	0.001
Faeces, mg/d	43.39	47.28	49.27	1.33	0.192
Apparent absorption, %	72.00^{c}	81.00^{a}	75.00^{b}	1.00	0.001
Urine, mg/d	40.44^{a}	26.92^{b}	33.47^{ab}	2.28	0.019
Total excretion	83.83^{a}	74.21^{b}	82.74^{a}	1.82	0.027
Balance, mg/d	70.55^{c}	174.24^{a}	116.80^{b}	15.60	0.000
% intake	45.50^{c}	70.01^{a}	58.44^{b}	3.67	0.000
µg/kg $BW^{0.75}$	646.63^{c}	1603.63^{a}	1090.40^{b}	139.5	0.000
Cobalt (Co), mg/d					
Feed	119.06^{b}	140.20^{ab}	152.15^{a}	5.75	0.025
Drinking water	0.2433^{b}	0.2900^{a}	0.2133^{b}	0.01	0.009
Total intake	119.31^{b}	140.49^{ab}	152.36^{a}	5.75	0.025
Faeces, mg/d	25.83^{b}	39.41^{a}	37.87^{a}	2.59	0.031
Apparent absorption, %	78.33	72.00	75.00	1.01	0.170
Urine, mg/d	6.50^{a}	2.16^{b}	3.24^{b}	0.70	0.002
Total excretion	32.33	41.57	41.11	2.13	0.128
Balance, mg/d	86.98^{b}	98.92^{ab}	111.25^{a}	4.67	0.084
% intake	72.98	70.37	72.84	1.12	0.629
µg/kg $BW^{0.75}$	797.73^{c}	911.43^{b}	1036.27^{a}	35.99	0.001

**Apparent absorption % = (intake of the element – faecal element output) as % of intake of the element (Reid 1980). a,b,c Means followed by different letters within each same row are significantly different.*

It could be concluded that, the quantity of a nutrient element utilized by camels depends on its metabolic functions and varies widely from element to element moreover; source of energy has significant effect on mineral utilization through affecting on both DM and free water intake. Furthermore, Hassan et al. (2008) found that mineral solubility from feeds or range plants is the primary factor for their absorption by animal. Solubility of minerals may be affected by type of element (Na, K, and Zn), fiber content, anti-nutritional factors (phytic acid), particle size of feeds and rumen fluid pH.

Mineral status in the blood serum

The mean serum concentrations of major elements (sodium and potassium) and minor elements (Cu, Zn, Co) are shown in Table (7). The serum concentrations of sodium and potassium were not significantly affected by the source of energy supplemented in camel diets. The values of serum Na concentrations (meq/l) were 127.5, 128.87 and 145.97 while values of k were 3.72, 3.67 and 3.94 for camels fed on H, B and BD diets, respectively. Sodium ions, principally extracellular, are important in maintaining osmotic pressure, acid base balance and membrane potential (Abu Damir, 1998). The experimental results of serum Na concentrations are in the range values (54 to196 meq/l) of serum Na concentration of adult female camels (aged 5-9 years old) which was found by Yagil and Berlyne (1976) and Hussein *et al.* (1982). The higher values of sodium concentration of the experimental female camels are in agreement with previous reports that sodium is generally higher in camel serum when compared with other ruminants (Ayoub et al., 1960; Abdalla *et al.*, 1988). In regard to blood K concentration, the present data was within the range reported by Eltahir et al (2010) which was 3.22 – 8.7 meq/l. Most of the present results obtained for camel mineral concentrations were in agreement with the results of the previous studies of Wahbi *et al.* (1979); Hussein *et al.* (1982) and Abdalla *et al.* (1988). However, it was lower than those reported by Sarwar *et al.* (1992) who found that, the mean values of sodium (Na) and potassium (K) were 178.4 and 5.41 meq/l, respectively. They also found that serum potassium was lower in lactating than in dry females.

Table (7): Blood concentration (meq/l) of some major and minor elements for camels fed on different energy sources supplements.

Item	Experimental diets			SEM	P value
	H	B	BD		
Major elements					
Na	127.50	128.87	145.97	15.23	0.392
K	3.72	3.67	3.94	0.10	0.562
Minor elements					
Cu	17.30^{b}	24.30^{a}	22.17^{a}	1.13	0.005
Zn	154.0	202.7	179.0	10.91	0.200
Co	7.33^{ab}	10.67^{a}	5.00^{b}	0.96	0.018

H: Hay ad lib., B: Barley 100% of MER + Hay ad lib., BD: B: Barley 50% of MER + Date stones 50% of MER + Hay ad lib., SEM: Standard error mean.

A,b,c Means followed by different letters within each same row are significantly different.

Mean serum Cu and Co concentrations of camels fed on B ration were higher (P<0.05) when compared with the Cu and Co serum values of H and BD camel groups. The values of Cu and Co were 17.30 – 7.33, 24.30 – 10.67, 22.17 – 5.00 meq/l for camels fed on H, B and BD diets, respectively.

The difference in mean serum Zn concentration between the three groups was not statistically significant as affected by energy sources supplement for the whole period of the experiment. The values were 154.0, 202.7 and 179.0 meq/l for camels fed on H, B and BD diets, respectively. The higher present result of camel Zn serum concentration may be due to that Zn serum level increased with age and this could be attributed to the high Zn-binding enzymes necessary for growth and development (Ahmed *et al.*, 2003). Moreover, Zn as an enzyme activator for carbonic anhydrase necessary is for the growth of the germinal and somatic cells (Underwood, 1977) and carbonic peptidases is necessary for bone formation (Virgil and Mervin, 1970).

The normal plasma copper concentration for camel is considered to be 70-120 mg/dl (= 22.0 – 37.8 meq/l) and values below 60 mg/dl (= 18.9 meq/L) indicate deficiency (Abu Damir, 1998). Serum Cu concentration in Egyptian adult camels are ranging from 76 to 92 mg/100 ml (= 23.9 – 28.9 meq/L)

(Abdel Moty et al., 1968), while it was 50 – 92 mg/100 ml (= 15.7 – 28.9 meq/L) in Saudi Arabian camels (Hussein et al., 1982).

Mean serum Zn concentrations are 135 mg/dl (= 41.3 meq/l) in Egyptian camels (El-Tohamy *et al.*, 1986); 100.5 mg/dl(= 30.7 meq/L) in Ethiopian camels (Faye et al., 1986); 1073 mg/dl (= 323.1 meq/l) in camels from Morocco (El Kasmi, 1989) and 104.89 mg/dl (= 32.1 meq/l) in Sudanese camels (Abu Damir et al., 1993). These levels fall within the general range reported for other animals (70-120 mg/dl (= 21.4 – 36.7 meq/l); Underwood, 1977 and Alazzeh and Abu-Zanat, 2004). The wide variation in blood Zn concentration reported in the present study and others may be due to one or more of the following reasons; physiological status of animals, age, sex, salinity of water intake and type of feed offered or feeding level furthermore sampling time.

Cobalt level in plasma is too low to be the subject of clinical investigation. However, cobalt is essential for the synthesis of cynanocobalamine (Vit B12) by the rumenal microflora. No data are available regarding to cobalt plasma levels in dromedary camels. However, Burenbayer (1989) reports values between 3.39-13.16 µg/dl (= 0.001 – 0.004 meq/l) in Bactrian camels, depending on the season and mineral composition of the diet, however he does not detail the method of measurement used. Further investigations are necessary to understand the metabolism of trace elements in camels to precise the needs of this animal on trace elements.

CONCLUSION

It could be concluded that camels supplemented either by crushed barley grains or crushed date stones improved their utilization of water and mineral elements under study (Na, K, Cu, Zn, Co).

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تأثير إضافة مصادر طاقة إلى علائق الإبل المغذاة دريس برسيم كعليقة أساسية على: 2- التمثيل الغذائي للماء وبعض العناصر المعدنية.

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إستخدم في هذا البحث ثلاث نوق في نظام مربع لاتيني 3 × 3 بهدف دراسة تأثير إضافة حبوب الشعير ونوى البلح المجروش كمصادر طاقة رخيصة الثمن في علائق الإبل التي تغذى على دريس برسيم كعليقة أساسية ومدى تأثير ذلك على التمثيل الغذائي للماء وبعض العناصر المعدنية. غذيت الإبل على ثلاث علائق الاولى (المقارنة) دريس برسيم للشبع ، العليقة الثانية مجروش حبوب الشعير تغطي 100% من احتياجات الحيوان من الطاقة الحافظة بالإضافة إلى دريس برسيم للشبع أما العليقة الثالثة فهي نفس العليقة الثانية مع تغطية الاحتياجات من الطاقة الحافظة من كل من الشعير ونوى البلح المجروش بنسبة 50% من كل منهما.

أوضحت النتائج أن الإبل المغذاة على العليقة الثانية أظهرت تفوقا معنويا (على مستوى 1%) في كل من ماء الشرب والماء المحتجز (مل / كجم^{0,82}) مقارنة بالمجموعتين الاخرتين وكانت القيم 138,7 – 95,52 للمجموعة الثانية ، 115,3 – 55,41 للمجموعة الاولى ، 104,3 – 54,22 للمجموعة الثالثة. كذلك تفوقت إبل المجموعة الثانية معنويا في المحتجز من عناصر الصوديوم والبوتاسيوم والزنك بينما تفوقت المجموعة الثالثة في عنصر الكوبالت المحتجز.

أدت اضافة مصادر طاقة إلى خفض معنوي لماء الشرب المستهلك المنسوب إلى كل من المأكول من المادة الجافة ، المأكول من العناصر الغذائية الكلية المهضومة ، البروتين المهضوم ، النيتروجين المحتجز والنيتروجين المهضوم. أظهرت إبل المجموعة الثانية تفوقا معنويا في الحتجز من ماء الشرب المنسوب إلى كل من المأكول من المادة الجافة ، المأكول من العناصر الغذائية الكلية المهضومة ، البروتين المهضوم ، النيتروجين المحتجز والنيتروجين المهضوم.

يتضح من هذه الدراسة أن إضافة مصادر طاقة (خاصة حبوب الشعير) إلى علائق الإبل المغذاة على دريس برسيم تؤدي إلى تحسين التمثيل الغذائي للماء والعناصر المعدنية.